Conditional Correlation on CEE Stock Markets

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Abstract

An investigation into the stock market convergence of Czech Republic, Hungary, Slovakia and Romania reveals that capital market correlation level has strongly increased after the EU accession. The present study evaluates stock market co-movements in Czech Republic, Hungary, Slovakia and Romania on the basis of multivariate generalized autoregressive conditional heteroscedasticity models. The diagonal BEKK model is also employed in analyzing the convergence of the selected countries' stock markets with those existing in the developed countries; the analysis encompassed the 2002-2012 timeframe. The empirical results indicate that the correlation of the four CEE stock markets are strongly influenced by two factors: their accession to the EU and the 2007-2008 financial crisis.

Key words: stock index returns, multivariate GARCH, conditional correlation, diagonal BEKK, financial crises
J.E.L. classification: G12, C58, C32, G01

1. Introduction

Fama theory (1970) describes stock market efficiency as being dependent on the speed and accuracy with which information is encapsulated in the prices of various financial instruments. The pre- and post-EU-accession market efficiency of Czech Republic, Hungary and Poland have been thoroughly studied by several scientific articles. Romania joined the European Union three years after the above mentioned Central Eastern European countries, so we can verify our hypothesis that joining the European Union has led to significant increase in conditional correlation with the other countries.

The study investigates market co-movements manifested by the European developed markets and the block of Hungary, Czech Republic, Poland and Romania. Empirical results confirm that correlational links of the CEE countries' stock markets varied over time depending on the global economic environment. Via observing asset returns fat-tailed distribution and the clustering behavior of volatility we managed to study a volatility spillover of the markets. We deployed the so-called MGARCH-BEKK model, a multivariate generalized autoregressive conditional heteroscedasticity model developed by Engle and Kroner.

2. Literature review

In the last 15 years and after the Asian crisis equity markets have become increasingly integrated in terms of asset pricing and asset trading in many developed and emerging countries. Amongst those markets, Euro area equity markets are an interesting subject of study due to the changes caused by the accession process. A great wealth of studies interpreted in terms of asset pricing the European equity market integration after the establishment of the Eurozone and the start of EU-accession process of Central and Eastern Europe. Co-movements between developed countries and Asian emergent markets were depicted using a diagonal VECH GARCH model by Karunanayeke et al. (2010), they pointed out that the Asian crisis and the 2008-2009 financial upheaval were associated with the growth of the volatilities of stock market indices. Moreover, the

authors could identify a presumable transmission of volatility from US towards South-Eastern Asian and Australia.

Xiao and Dhesi (2010) studied the transmission of volatilities and time-varying correlations between France, Germany, United States and United Kingdom in the period before the 2008-2009 global crisis. They based their research on the diagonal VECH, GARCH-BEKK and DCC models and concluded that France and Germany are rather strongly correlated, while UK acted as a volatility transmission channel between US and Europe.

The transformations of capital market return correlations were studied with Generalized Spectral Test for serial dependence by Escanciano and Velasco (2006) and also by Todea and Lazar (2012). Conditional correlation dynamics was also analyzed via cross-sectional dependence analysis by Harrison, Lupu and Lupu (2010) and with non-linearity test method by Karadigli and Donmez (2012). Nistor et al. (2012) and Harrison and Moore (2010) examined the changes in conditional correlation using an Engle-Granger causality test for short-term relationships and the Johansen cointegration model for long-term dependence. Stock return co-movements of developed and emergent European capital markets (2005-2012) were studied using MGARCH-BEKK and diagonal VECH models by Horvath and Petrovski (2012), they observed an increased level of correlation in the case of developed countries.

Correlations between Central and Eastern European emergent markets were analyzed by Dajcman and Festic (2012), they did not take into account the heteroskedasticity in the time series. The co-integration level of the developed countries is higher than in the case of the emerging countries. Romanian researchers Stoica and Diaconaşu (2013) concluded that the crisis did not affect the degree of financial market integration. They applied a generalized autoregressive conditional heteroscedasticity and a Value at Risk model for comparing stock market indices of nine European emerging markets with the performance of markets in four developed countries.

An asymmetric DCC-Garch model was used by Guido and Gupta (2010), Gjika and Horvath (2012) to analyze the co-movements of CEE markets in the period 2001-2011.

3. Data and methodology

3.1. Data

Four countries were selected for the study of the conditional correlation: three of them (Hungary, Slovakia and the Czech Republic) joined the EU in the first wave of 2004, Romania became EU member in 2007. The study period is January 2002 – June 2012, weekly returns (using Friday closing prices) were calculated. Stock returns of the selected countries were studied with cross correlation methods.

The comparison of variations in regional stock market returns with the stocks volatility of developed markets was based on the closing prices of the German market (DAX), United Kingdom (FTS), Austria (ATX), Greece (ASE) and the Morgan Stanley MSCI-indices provided by the Thomson Data Stream: EAFE – European developed market indices, EM – global emerging markets indices.

For the purpose of studying the dynamic variation of the average conditional correlation time series were split into four periods:

1. January 2002 – April 2004 (before EU-accession of three country)
2. May 2004 – February 2008 (before crisis)
3. March 2008 – August 2009 (crisis period)
4. September 2009 – June 2012 (post crisis period)

3.2. Methodology

In the modeling process of short-term correlations of stock indices a diagonal MGARCH-BEKK method was applied. The MGARCH model is adequate, because inter-correlated contemporaneous shocks can influence the results.

The diagonal multivariate MGARH models mean equation is:

$$r_t = \mu + u_t$$

where r_t is a stock return series, the unconditional mean vector is μ. Consequently $E(r_t/\Omega_{t-1}) = \mu_t$ and u_t is the shock of the return series at time *t*. Starting from $var(r_t/\Omega_{t-1}) = H_t$ is an nxn conditional variance-covariance matrix of the shocks we deduce the shocks as $u_t = H_t^{0.5} v_t$, where $vt \approx iid(0, I_k)$. For the shocks a multivariate t-distribution was applied, because empirical findings showed that the shocks fitted with multivariate Gaussian distribution failed to properly model the kurtosis in the return series.

The MGARCH-BEKK model developed by Baba, Engle et al. (1995) supposes that the diagonal elements in C matrix are restricted to be positive, which is not an obligation in the DVECH model. The model allows for volatility spillovers, so that the shock in the variance of one variable influences the others.

The MGARCH-BEKK model specification is

$$H_t = C'C + A'\varepsilon_{t-1}\varepsilon'_{t-1}A + B'H_{t-1}B$$

where A and B are parameter matrices with dimension *nxn*, the intercept matrix is decomposed in CC′, where C′ is an upper triangular matrix and C is the lower triangular matrix of the parameters. Without any further assumption CC′ is positive semidefinite. While the original model is more general, in practice the MGARCH-BEKK models are definitely of order 1. This kind of models can be difficult to estimate especially with more than six assets. The convergence was achieved with good t-values for the parameters, but for more than six assets the convergence failed.

Similar to a DVECH model, there is a diagonal and a scalar version of the MGARCH-BEKK model. The diagonal form assumes that the A_{kj} and B_{kj} are diagonal, while the most restricted version is the scalar BEKK, where A=aI and B=bI and *a* and *b* are scalars. Since the diagonal BEKK model assumes the matrices A and B are diagonal, thus makes it possible for H_t to be positive definite for all *t*. Since a full BEKK model is appropriate for a maximum number of five assets, the usage of a diagonal BEKK is suitable for empirical analyses (Silvennoinen and Terasvirta, 2008). We could calculate the conditional correlations of pairs of indices to estimate the degree of co-movements of the markets, using the conditional correlation formula:

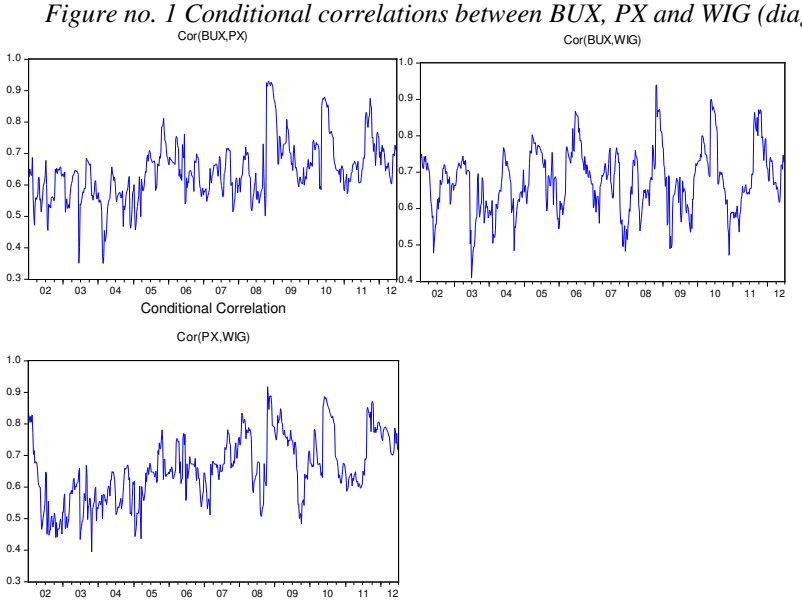
$$\rho_{xy,t} = \frac{h_{xy,t}}{\sqrt{h_{xx,t}h_{yy,t}}}$$

4. Empirical results

In the first phase the evolution of the conditional correlations (between the returns of Budapest Stock Exchange, Prague Stock Exchange, Warsaw Stock Exchange and Bucharest Stock Exchange, January 2002 – June 2012) were studied with a multivariate GARCH model – a diagonal BEKK –, with Student distribution for the errors for addressing the fat tails of the returns especially the left tail which stands for the negative returns. The results indicated that Prague Stock Exchange (PX), Warsaw Stock Exchange (WIG) and Budapest Stock Exchange (BUX) indices presented higher numbers in terms of their co-integration than in terms of their integration with the Bucharest capital market index (BET).

The conditional correlations of the Czech Republic (PX), Hungary (BUX) and Poland (WIG) are presented in figure 1.

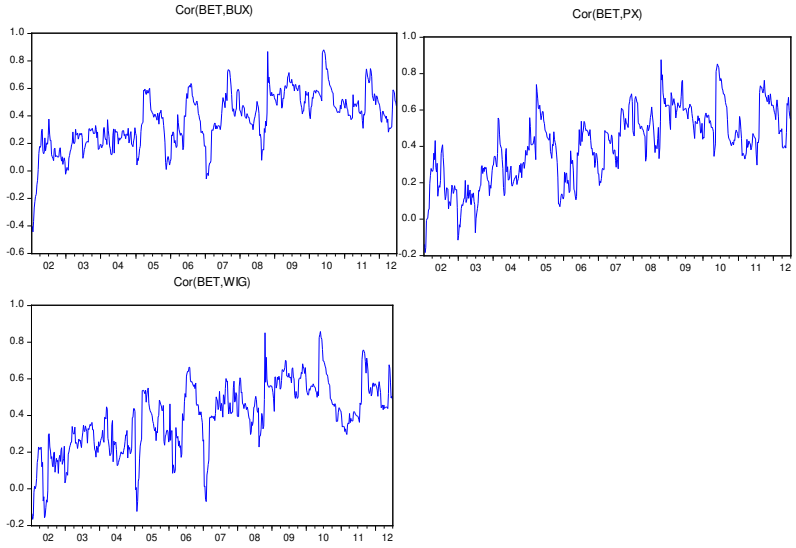
Figure no. 1 Conditional correlations between BUX, PX and WIG (diagonal BEKK)



Source: Own projection

The correlations among Bucharest Stock Exchange (BET) and Prague Stock Exchange (PX), Budapest Stock Exchange (BUX), Warsaw Stock Exchange (WIG) are shown in figure 2.

Figure no. 2 Conditional correlations between BET and BUX, PX, WIG (01.2002-06.2012)



Source: Own projection

The mean conditional correlations for the main indices of the four CEE countries for the entire period are pictured in Table 1.

Table no. 1 – Conditional correlation averages of the four CEE indices (01.2002-06.2012)

Indices	BUX	PX	WIG	BET
BUX	1,000			
PX	0,617	1,000		
WIG	0,668	0,632	1,000	
BET	0,383	0,415	0,400	1,000

Source: Own projection

A diagonal BEKK model was fitted for each period to form a proper image over the dynamics of the conditional correlations of returns. A trend of increasing market integration was identified by averaging the conditional correlations, a trend influenced by the process of EU enlargement and by the external shocks following the outbreak of the financial global crisis. The graphs below show that in the first month of the crisis, after 19 September 2008, there was a powerful increase in the conditional correlation across markets and that after 17 October 2008 the market integration began to lose force. Two powerful jumps in conditional correlations could be grasped: the first one occurred in the April–May 2010 period and the other one surfaced in the July–August 2011 timeframe. Both of them may be linked to the sovereign debt crisis, the first one was right at the outbreak of the Greek crisis, while the second shock was caused by the EU summit, where solutions to the Greek crisis were proposed.

Table no.2 Mean of conditional correlation for the four emerging markets in each period

Indices	Period	BUX	PX	WIG	BET
BUX	2002/01-2004/04	1,000	0,501	0,555	0,122
	2004/05-2008/02	1,000	0,636	0,702	0,337
	2008/03-2009/08	1,000	0,683	0,629	0,542
	2009/09-2012/06	1,000	0,764	0,757	0,600
PX	2002/01-2004/04		1,000	0,463	0,108
	2004/05-2008/02		1,000	0,639	0,354
	2008/03-2009/08		1,000	0,727	0,614
	2009/09-2012/06		1,000	0,746	0,590
WIG	2002/01-2004/04			1,000	0,104
	2004/05-2008/02			1,000	0,348
	2008/03-2009/08			1,000	0,583
	2009/09-2012/06			1,000	0,624
BET	2002/01-2004/04				1,000
	2004/05-2008/02				1,000
	2008/03-2009/08				1,000
	2009/09-2012/06				1,000

Source: Own projection

In the third phase of the study conditional correlations of the four CEE countries with other developed market economies (such as Austria, Germany, United Kingdom, Greece) were analyzed. Market returns were also compared by using aggregated indices as Morgan Stanley's MSCI-EAFE and MSCI-EM.

Table no. 3 Conditional correlation averages of CEE indices with other markets (01.2002-06.2012)

Indices	EAFE	EM	ATX	DAX	FTSE	ASE
BUX	0,503	0,566	0,553	0,506	0,464	0,426
PX	0,508	0,549	0,643	0,523	0,536	0,532
WIG	0,507	0,568	0,503	0,547	0,512	0,456
BET	0,288	0,357	0,392	0,292	0,292	0,244

Source: Own projection

The means of the conditional correlations indicate that markets of Prague, Budapest and Warsaw have a higher integration than the Bucharest one. The four studied stock markets, except for the Polish capital market, have a high integration with the Austrian capital market, but the Polish index is more in tune with the German index (DAX). The dynamic of market integration can be seen in table 4.

Table no. 4Average of conditional correlation of the four CEE capital markets with other markets on each period

Indices	Period	EAFE	EM	ATX	DAX	FTSE	ASE
BUX	2002/01-2004/04	0,133	0,206	0,263	0,353	0,336	0,227
	2004/05-2008/02	0,517	0,600	0,612	0,495	0,482	0,456
	2008/03-2009/08	0,684	0,677	0,754	0,713	0,597	0,609
	2009/09-2012/06	0,683	0,724	0,677	0,579	0,505	0,525
PX	2002/01-2004/04	0,128	0,190	0,243	0,323	0,355	0,430
	2004/05-2008/02	0,569	0,625	0,711	0,510	0,542	0,547
	2008/03-2009/08	0,646	0,660	0,810	0,741	0,654	0,718
	2009/09-2012/06	0,663	0,670	0,749	0,612	0,597	0,485
WIG	2002/01-2004/04	0,183	0,245	0,191	0,507	0,412	0,398
	2004/05-2008/02	0,542	0,614	0,606	0,544	0,572	0,433
	2008/03-2009/08	0,604	0,625	0,632	0,654	0,525	0,747
	2009/09-2012/06	0,697	0,738	0,667	0,620	0,615	0,501
BET	2002/01-2004/04	0,005	0,058	0,179	0,069	0,119	-0,064
	2004/05-2008/02	0,198	0,284	0,341	0,188	0,243	0,259
	2008/03-2009/08	0,576	0,628	0,661	0,567	0,516	0,568
	2009/09-2012/06	0,521	0,562	0,504	0,439	0,441	0,424

Source: Own projection

5. Conclusions

The present paper studied the degree of integration in the emerging capital markets of the Central and Eastern European block (Czech Republic, Poland, Hungary and Romania) in the January 2002 – June 2012 interval. The analysis was realized with a diagonal MGARCH-BEKK using weekly data. Variations in conditional correlations were evidenced in four periods: before the first wave of EU enlargement in the region (the accession of Czech Republic, Hungary and Poland), the period prior to the financial global crisis of 2008-2009, the crisis years and the post-crisis era. Empirical results indicated that given the different moments of EU accession, the period of joining is easily identifiable in the plots of conditional correlations. The four countries became more integrated after joining the European Union.

Regarding the crisis years two divergent evolutions were identified: in the first month of the crisis, after 19 September 2008, there was a strong increase of the correlation across all stock markets, with a doubling in value in some cases, and right after 17 October 2008 the market integration decreased in correlation. In the post-crisis period two significant jumps of conditional correlations showed up: the first one around April-May 2010 was linked to the outbreak of the Greek sovereign debt crisis and the second shift, between July-August 2011, appeared after the European Union summit dedicated to finding specific solutions to sovereign debt crisis of Greece.

High levels of correlation (of about 0.9) indicate the volatility spillover across countries. Significant temporary increases in correlation corresponded to uncertainties of capital markets and were correlated with the negative news that had concurrently effected all capital markets. The transition period following the end of the crisis was marked by a reversion process to a specific dynamics for each country, suggesting favorable arguments for using a DCC-Garch model or Markov Switching framework in future studies.

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